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# Artificial Intelligence

**Morris Variant - D**

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## PROBLEM STATEMENT:

**Part 1: MINIMAX:**
The first program (File: **MiniMaxOpening.py**) plays a move in the opening phase of the game using MiniMax algorithm. The second program (File: **MiniMaxGame.py**) plays in the midgame/endgame phase using MiniMax algorithm.

**Part 2: ALPHA-BETA:**
The first program(**ABOpening.py**) plays the opening game for white player using Alpha-Beta Pruning Algorithm. The second program(**ABGame.py**) plays in the midgame/endgame phase using Alpha-Beta Pruning Algorithm.

**PART 3: PLAY A GAME FOR BLACK**
Same programs as in Part 1, but now the game is played for a Black player and algorithm remains the same i.e. the MiniMax. The file **MiniMaxOpeningBlack.py** is used for the opening phase and **MiniMaxGameBlack.py** is used for midgame/endgame phase.

**PART 4: STATIC ESTIMATION**
The improvised version of static estimation function which provides better results compared to MiniMax Algorithm using the default static estimation function.

**Improved Static Estimation:** In Opening game, the station estimation is calculated by calculating the number of white and black pieces and then subtracting the number of black pieces by the number of white pieces. For the mid game, we give the estimate according to number of white and black pieces (3 or 2) as explained in the handout. In the improved version, we consider the case of forming a mill by giving more weight to the position that would lead to forming a mill and hence reducing the number of steps to win the game. So while considering the next move to be performed, the position which forms a mill is more likely to be considered and thus increasing the chances of winning the game.
      The function **staticEstimateOpeningImproved()** , the improved static estimation function used in the **MiniMaxOpeningImproved.py** and **MiniMaxGameImproved.py** contains the logic for the improved static estimation calculation.

## RESULTS:
**Case 1:** Comparison between static estimation given in handout and the improved one for the opening phase of the game.

**Input:**
BWBxxxBWWWWBxBWBxBxWWxB

**Output:**
**MiniMaxOpening:**
Board Position: BWBWBWBWBWWxxxWBxBxWWxB
Position evaluated by static estimation: 638
MINIMAX Estimate: 0

**MiniMaxOpeningImproved:**
Board Position: BWBWBWBWBWWxxxWBxBxWWxB
Position evaluated by static estimation: 638
MINIMAX Estimate: 1

**Case 2:** Comparison between static estimation given in handout and the improved one for the midgame/endgame phase of the game.

**Input:**
BWBWBWBWBWWxxxWBWBxxWxB

**Output:**
**MiniMaxGame:**
Board Position: BWBWBWBWBWWxxxWBxBxWWxB
Position evaluated by static estimation: 43
MINIMAX Estimate: 986

**MiniMaxGameImproved:**
Board Position: BWBWBWBWBWWxxxWBxBxWWxB
Position evaluated by static estimation: 43
MINIMAX Estimate: 1986

**Case 3:** Comparison between the results of MiniMax and Alpha-Beta Pruning

**(a) Input:** BWBWBWBWBWWWxxWBWBxxxxB

**MiniMaxOpening:**
Board Position: BWBWBWBWBWWWWxWBWBxxxxB
Position evaluated by static estimation: 670
MINIMAX esitmate: 1

**ABOpening:**
Board Position: BWBWBWBWBWWWWxWBWBxxxxB
Positions evaluated by static estimation: 93
AB Estimate: 1

**MiniMaxGame:**
Board Position: BWBWBWBWBWWxWxWBWBxxxxB
Position evaluated by static estimation: 703
MINIMAX Estimate: 991

**ABGame:**
Board Position: BWBWBWBWBWWxWxWBWBxxxxB
Positions evaluated by static estimation: 322
AB Estimate: 991

**MiniMaxOpeningImproved:**
Board Position: BWBWBWBWBWWWWxWBWBxxxxB
Position evaluated by static estimation: 670
MINIMAX Estimate: 2

**MiniMaxGameImproved:**
Board Position: BWBWBWBWBWWWxxWBxBxWxxB
Position evaluated by static estimation: 703
MINIMAX esitmate: 2993


**(b) Input:** WWBxxxBWWWWBxBWBxBxWxxB

**MiniMaxOpening:**
Board Position: WWBxxxBWWWWBWBWBxBxWxxB
Position evaluated by static estimation: 1103
MINIMAX esitmate: 3

**ABOpening:**
Board Position: WWBxxxBWWWWBWBWBxBxWxxB
Positions evaluated by static estimation: 205
AB Estimate: 3

**MiniMaxGame:**
Board Position: WWBxxxBWxWWBxBWBxBxWWxB
Position evaluated by static estimation: 877
MINIMAX esitmate: 1990

**ABGame:**
Board Position: WWBxxxBWxWWBxBWBxBxWWxB
Positions evaluated by static estimation: 197
AB estimate: 1990

**MiniMaxOpeningImproved:**
Board Position: WWBxxxBWWWWBWBWBxBxWxxB
Position evaluated by static estimation: 1103
MINIMAX esitmate: 4

**MiniMaxGameImproved:**
Board Position: WWBxxxBWxWWBxBWBxBxWWxB
Position evaluated by static estimation: 877
MINIMAX esitmate: 3986

**Case 4:** Below is the output of all programs for a given input case.

**Input:**
WWBxxxBWWxxBWBWBxBxWxxB

**MiniMaxOpening:**
Board Position: WWBxxxBWWxxBWBWBxxxWWxB
Position evaluated by static estimation: 1632
MINIMAX esitmate: 3

**AB Opening:**
Board Position: WWBxxxBWWxxBWBWBxxxWWxB
Positions evaluated by static estimation: 478
AB Estimate: 3

**MiniMaxOpeningImproved:**
Board Position: WWBxxWxWWxxBWBWBxBxWxxB
Position evaluated by static estimation: 1632
MINIMAX esitmate: 4

**MiniMaxOpeningBlack:**
Board Position: WWBBxxBWWxxBWBWBxBxWxxB
Position evaluated by static estimation: 1384
MINIMAX esitmate: 0

**MiniMaxGame:**
Board Position: WWBxxWBxWxxBWBWBxxxWxxB
Position evaluated by static estimation: 1338
MINIMAX esitmate: 991

**ABGame:**
Board Position: WWBxxWBxWxxBWBWBxxxWxxB
Positions evaluated by static estimation: 290
AB estimate: 991

**MiniMaxGameImproved:**
Board Position: WWBxxWBxWxxBWBWxxBxWxxB
Position evaluated by static estimation: 1338
MINIMAX esitmate: 2991

**MiniMaxGameBlack:**
Board Position: WWxxxBBWWxxBWBWBxBxWxxB
Position evaluated by static estimation: 1364
MINIMAX esitmate: -8

## CONCLUSION:

1. Alpha-Beta Pruning Algorithm (ABOpening and ABGame) evaluates less nodes compared to MiniMax Algorithm (MiniMaxOpening and MiniMaxGame).
2. The improvised version of the static estimation function optimizes MiniMax Algorithm to perform better.

## REFERENCES:

Handouts provided in class (Morris Variant D)